Swami Ramanand Teerth Marathwada University Nanded

**Name of research topic :**

# "Tailoring the electrical and magnetic properties of strontium hexaferrite by doping at Fe site"


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## Name of Research Guide


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## 1. Introduction:

Ferrites are ceramic materials, black or dark gray in appearance, very hard and brittle. The story of ferrites begins with the need of ferromagnetic materials of high resistivity to obtain reasonable eddy current losses. Even after more than half of the century the scientist, researchers, technologist, and engineers are still enthusiastic in various types of bulk as well as nanocrystalline ferrite materials. The recent trend is focused on the doped ferrite prepared using various synthesis techniques with different cation substitution which in turn affects the various properties like, electrical, microwave absorbing and dielectric behavior.

Ferrite materials are clssified in to three types such as spinel, garnet and hexaferrites. Hexaferrites are classifified into five types depending on their chemical and crystalline structure. These include M, W, Y, X and Z hexaferrites with general formulae $BaFe_{12}O_{19}$, $BaMe_2Fe_{16}O_{27}$, $BaMe_2Fe_{12}O_{22}$, $Ba_2Me_2Fe_{28}O_{46}$ and $Ba_2Me_2Fe_{24}O_{41}$ respectively, where Me represents any divalent element [1]. The $SrFe_{12}O_{19}$ is one of the M type hexaferrites and belong to magneto plumbite group. The unit cell of hexaferrites contain 38 $O_2$ ions and 2 $Sr^{2+}$ ions and 24 $Fe^{3+}$, the Fe ion distributed in octahedral

(12k,2a,4f2), tetrahedral (4f1) and trigonal pyramide site (2b). The molecular unit of M type hexaferrites is made of one S and one R block, with an overlap of hexagonally and cubically packed layers, S block consists of two spinel units and R block consists of three hexagonally [2]. M type Barium and strontium hexaferrites is one of important classes of permanent magnetic materials, relatively large saturation magnetization (Ms), high coercive force (Hc) and high magnetic anisotropy field as well as excellent chemical stability, corrosion resistivity and high frequency microwave absorption materials [3-5].

Doping is important factor that affects the properties of the strontium ferrites. Doping is usually carried out according to the desired applications. Doping of rare earth metals such as La has been reported to enhance the magnetic properties of the strontium ferrite. Permanent magnets are crucial materials for the operation of engines and basic elements in turbines used, for example, for the power generation in wind, hydro or thermal power plants. The constant technological demand for these materials leads to an overall production of around 500,000 tons per year, with a high tendency to continue increasing [6].

Different types of applications require a particular property. For application as permanent magnet it has to be magnetically hard with high remanence and coercivity. Microwave (MW) require magnetically softer material with high electrical resistivity and low eddy current, while high saturation magnetization and high coercivity value (~1000-3000Oe) is

requirement of high density recording media material [7]. However structural and magnetic properties of hexaferrite were found to be strongly dependent on the fabrication method as well as on the substitution of Fe or Sr/Ba with ions of different nature and doping concentration.

## 2. Literature review

Microstructural, magnetic and electrical properties of hexaferrites are considered as important parameters in deciding the significance of these materials for their technological consideration, out of which magnetic behavior is considered as the most important parameter. These properties have been found to be sensitive to their compositional and preparatory techniques.

Hexagonal ferrite are used for the manufacture of high-frequency transformers, microwave electronics devices, as active elements in magnetic memory devices, in new functional sensors such as plastoferrites, as magnetic fluids, permanent magnets, multiferroics [8]

To date, several research works have been carried out to improve the magnetic properties of Sr/Ba hexaferrite, by substitution of ions such as La-Zn, La, Mg, Mn, Sn, Zr and Co in the hexaferrite structure [9–15]. Majid Jamalian [16] investigated the structural magnetic properties of strontium hexaferrite $SrFe_{12-x}(SnTb)_{x/2}O_{19}$($x=0–2$). He found that Ms increased with the rise of Sn– Tb doping amount. The x=2 sample had an Ms of 41.37emu/g,while that of the x=0 sample was 30.61emu/g. This was because $Fe^{3+}$ ions with more

magnetic moment (5μB) were substituted by the Sn4+ –Tb4+ ions with zero magnetic moment at octahedral sites having downward spin,4f2, (4f2 had an opposite spin relative to other octahedral sites). Therefore, the increase in saturation magnetization could be due to the replacement of $Fe^{+3}$ from 4f2 sites by nonmagnetic $Sn^{+4}$ and $Tb^{4+}$. M. J. Iqbal etal. substituted the Ni-Ce ions into Sr-Ba hexferrite [17], and A. Haq etal studied on the magnetic properties and their frequency based applications of Pb substitutes $BaFe_{12}O_{19}$ hexaferrite [18].

## 3. Objective of the present work

The objective of this study is to prepare magnetic materials with doping of elements at Fe site and study its structural, electrical and magnetic properties. Following objective has been set to complete present work.

1] To synthesis Strontium Hexaferrite nanoparticles doping at Fe site by chemical method such as Sol-gel, Hydrothermal, etc.

2] To investigate the phase formation and structural parameter by

- X-ray diffraction technique (XRD)
- Transmission electron microscopy (TEM)
- Scanning electron microscopy (SEM)
- Infrared spectroscopy (IR)

3] To study magnetic properties by

- Vibrating sample magnetometer (VSM)

4) To study the electrical properties such as

- Dielectric properties
- D.C. resistivity

**3. Methodology:**

There are many methods in the literature for the synthesis of hexaferrites compounds such as hydrothermal [19], co-precipitation, micro-wave induced combustion [20], mechano-combustion [21], salt assisted ultrasonic method [22].We will use sol-gel method to prepare sample. It is easy method for preparing nano particle at low temperature. In addition, recently this method has been found to be a very suitable method for the preparation of multi-component oxide materials at relatively lower temperatures. The major advantages of the method are not only to reduce the product formation temperature but also have good control over its homogeneity and their microstructures. To examine phase formation of the prepared sample, it is necessary to characterize the samples by XRD technique. Using XRD data the lattice parameter, X-ray density and particle size will be evaluated. The particle size of newly prepared samples will also be determined by transmission electron microscopy (TEM). The Infrared spectroscopy (IR) patterns will be used to study bond formation.The saturation

magnetization (Ms), Coercivity, and retentivity will be measured using vibrating sample magnetometer (VSM).

The dielectric properties with change in frequency will be carried out at room temperature on LCR-Q meter. D.C. electrical resistivity measurements of all the samples in the form of pellets will be carried out in the temperature range 300 to 800 K by two probe technique.

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